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Movement Patterns of Polynesian Rats (*Rattus exulans*) in Sugarcane[1]

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ABSTRACT: Movements of Polynesian rats (*Rattus exulans*) in a sugarcane field and adjacent gulch areas were determined both by livetrapping and radiotelemetry during various stages of the 2-year crop cycle. Both types of data showed that the rats were relatively sedentary. The average distance traveled between successive trap captures was 104 feet, and 65 percent of the successive captures were made within 75 feet of each other. Eighty-six percent of the radiotelemetry bearings located the rats within 300 feet of their burrows. Females moved less than males, and the home ranges of both sexes decreased as sugarcane matured. Initially, all rats lived in the gulches, although they foraged into the cane field at night. As the cane matured, more and more rats dug cane-field burrows. These movement data suggest that control programs to protect sugarcane from damage by rats should concentrate on adjacent noncrop areas in the early stages of the crop cycle and include the fields in the later stages.

SINCE the late 1800s, the Hawaiian sugarcane industry has sustained severe losses because of rat damage to sugarcane (Pemberton 1925, Doty 1945). Currently, estimates of rat-damaged stalks range up to 40 percent of the harvestable crop (Teshima 1968). The predominant rat species in Hawaiian sugarcane is the Polynesian rat (*Rattus exulans*), followed by the Norway rat (*R. norvegicus*) and the black rat (*R. rattus*). Our routine trapping has shown that, in the Hilo district on the island of Hawaii, Polynesian rats make up 96 percent of the rat population in immature sugarcane, 60 to 90 percent in mature sugarcane, and 75 percent in noncrop gulch areas adjacent to the sugarcane (Hood et al. 1970).

Because the Polynesian rat is probably the most important rat species damaging Hawaiian sugarcane, we conducted a study to determine the movement patterns of a Polynesian rat population during a typical 2-year crop cycle. Earlier movement studies of field rodents in Hawaii were conducted in an irrigated sugarcane region along the upper Hamakua coast on the island of Hawaii (Kartman and Lonergan 1955, Tomich 1970) and on a noncrop mountain slope on Oahu (Spencer and Davis 1950). In contrast, our work was conducted in nonirrigated sugarcane in the Hilo district on the island of Hawaii (Fig. 1). The climate is consistently warm and very humid. The mean annual temperature is 76° F and the annual rainfall varies from 120 to 200 inches.

METHODS AND MATERIALS

Field 3S, Mauna Kea Sugar Company, Hilo, Hawaii, was selected for this study because cane in this field usually has been severely damaged by rats. This 47-acre trapezoidal field is 2,560 feet long and varies from 720 feet wide at the lower end to 1,280 feet wide at the upper end (Fig. 2). Gulches 85 to 270 feet wide and 40 to 150 feet deep border the sides and lower end of the field; a sugarcane field borders the upper end. The dense gulch vegetation consists primarily of California grass (*Panicum purpurascens*), honohono grass (*Commelina nudiflora*), guava trees (*Psidium guajava*), melastoma shrubs (*Melastoma malabathricum*), and wild banana (*Musa* sp.). The study was started when the sugarcane was 7 months old. Livetrapping con-

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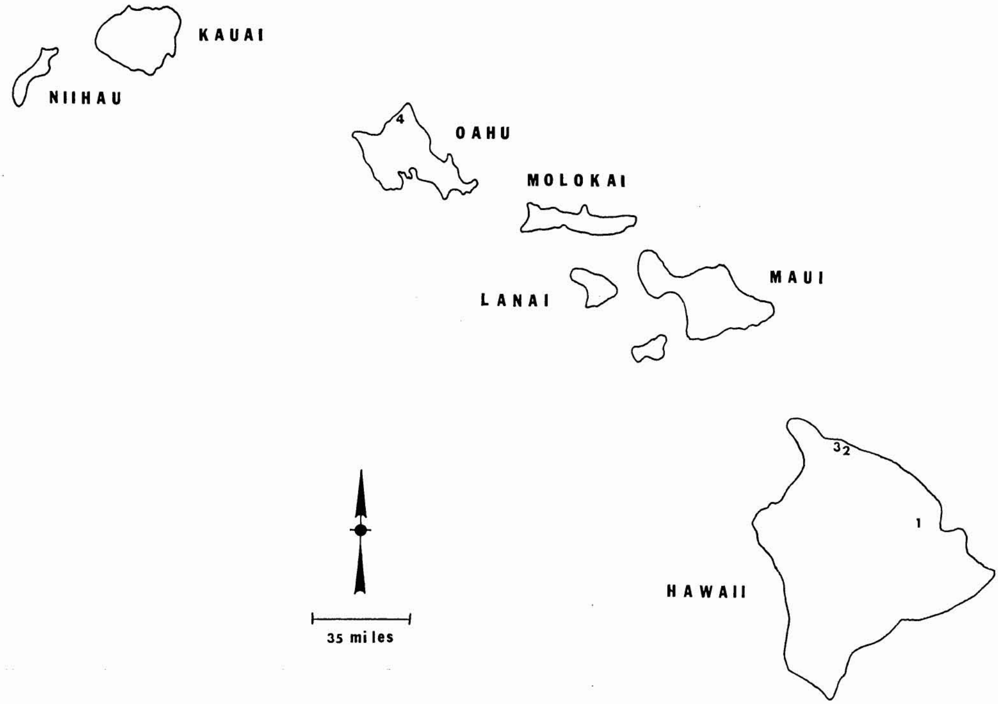

FIG. 1. State of Hawaii showing locations of Polynesian rat movement study areas. (1) This study, (2) Tomich 1970, (3) Kartman and Lonergan 1955, and (4) Spencer and Davis 1950.

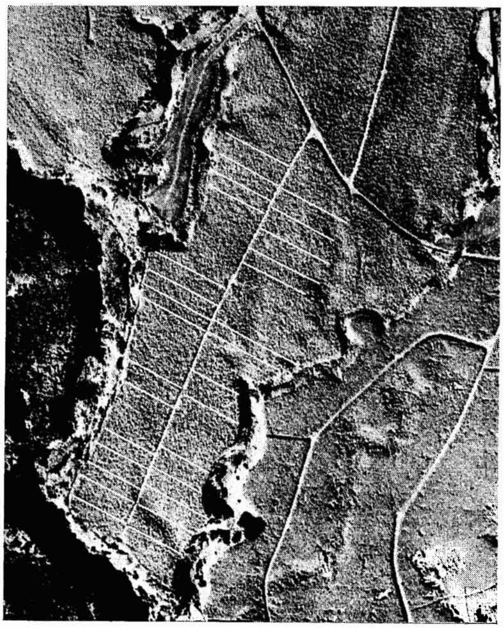

FIG. 2. Aerial view of the field used in the rat movement study showing arrangement of the 30 trapping transects.

tinued for 11 months (December 1967 through October 1968) and radiotelemetry for 16 months (December 1967 through March 1969).

Live Traps

Thirty parallel transects, 300 to 600 feet long, were established perpendicular to the side gulches when the cane was 6 months old; 25 of these ended at the gulches (Fig. 2). Distances between transects were randomly selected and ranged from 80 to 400 feet. Japanese live traps were spaced at 75-foot intervals along transects. At monthly intervals the traps were baited with fresh coconut meat and examined daily for 4 consecutive days. Captured rats were ear-tagged, and trap location, sex, age, and reproductive status were recorded before the rats were released at the capture site.

Radiotelemetry

This technique was used to determine movement patterns when the crop was 7, 10, 12, 15, and 22 months old. Adult rats captured from within the field were taken to the laboratory, anesthetized, fitted with 5-g transmitters, and released at the point of capture. Transmitters were constructed with circuits similar to those constructed by Dodge and Church (1965) and had a range of about 0.5-mile line-of-sight. Portable directional receivers, a Cochran D-11[6] and a modified Johnson Messenger 350 D/F, were used to monitor the signals. Occasionally, a vehicle-mounted R-388/URR military receiver was used to search for weak and lost signals. Most monitoring was done between dusk and dawn for 4 to 5 consecutive hours each night; observation periods were staggered from night to night so that movements and activity periods were recorded for all nighttime hours. The rats were also frequently checked during daylight hours.

Twenty-six rats, weighing 58 to 101 g, were monitored for an average of 8 days each (range 5 to 21). Either five or six rats were successfully followed during each cane age period. Rat locations were determined by triangulation from a road bisecting the 47-acre field and from the 30 transects that extended perpendicularly from the road. Home burrow locations were found by direct approach during daytime monitoring.

RESULTS

Livetrapping

Rat species composition in our study area was typical of the area. Of the 1,051 rats captured, 91 percent were Polynesian rats, 6 percent were black rats, and 3 percent were Norway rats. Altogether, 952 Polynesian rats were ear-tagged and released during the 11-month study. Of these, 431 (45 percent) were recaptured 695 times for an average of 1.6 recaptures per rat (range 1–13). This is a relatively low recapture figure and suggests that trap shyness and/or a too-large trapping grid influenced our results. Of the 695 recaptures, 250 (36 percent) occurred in the trap of previous capture and 452 (65 percent) occurred within 75 feet of the previous capture. For all rats, the average distance traveled between successive captures was 104 feet.

Average distances and time intervals between successive captures are summarized in Table 1. Movements of rats captured twice in succession in the same trap were recorded as 0 feet and are included in the averages. Recaptures occurring within each monthly 4-day trapping period (0–month) showed that males and females moved similar distances—about 95 feet. As the time interval between successive captures increased, males showed a tendency to increase their ranges; the average distances between successive captures increased, and the percentages of captures within 75 feet decreased. These figures remained relatively constant for females, indicating a tendency toward more restricted movement.

As the sugarcane matured, Polynesian rats showed a definite tendency toward decreased movement (Table 2). For males, this decrease was gradual until the cane was 13 to 15 months old and then dropped sharply the next 2 months. For females, the decrease began when the crop was 13 months old and continued downward the next 5 months. An increase in food and availability (maturing sugarcane), an increase in the rat population, or a combination of the two may have caused this reduction of movement.

Range maps (Fig. 3) and observed range lengths (ORL) are further evidence of Polynesian rats' sedentary habits. Stickel (1954) defined ORL as the longest straight-line distance between recapture points. For males, the average ORL was 149 feet (range 0 to 1,830); for females, it was 123 feet (range 0 to 1,700). Eighty-nine percent of the males and 92 percent of the females had ORL's of 300 feet or less; only four rats had ORL's greater than 880 feet. However, because the ORL's of these four rats were extremely large—1,450 to 1,830 feet—we believe that, instead of range lengths, these large distances probably represented dispersive moves. Unfortunately, none of these rats were captured again to determine if new home areas were established.

The longest move we recorded was for one female rat. We captured this rat five times in our study area from March 1968 to May 1968. Four months later (September 1968) we snaptrapped

[6] Use of trade names in this publication does not imply endorsement of commercial products by the federal government.

TABLE 1

AVERAGE DISTANCE BETWEEN SUCCESSIVE CAPTURES OF POLYNESIAN RATS AND PERCENT OF SUCCESSIVE CAPTURES AT THE SAME LOCATION AND WITHIN 75 FEET OF THE PREVIOUS CAPTURE, AT FIVE TIME INTERVALS

NUMBER OF MONTHS SINCE PREVIOUS CAPTURE	SEX OF RATS	NUMBER OF RECAPTURES	AVERAGE DISTANCE (FEET)	PERCENT RECAPTURES AT 0 FEET	PERCENT RECAPTURES WITHIN 75 FEET
0*	M	182	93	34	65
	F	209	96	37	68
1	M	95	110	31	58
	F	107	78	47	75
2	M	23	129	26	48
	F	30	92	33	73
3	M	9	293	33	44
	F	14	169	21	50
4–9	M	14	350	14	21
	F	12	87	42	58
Summary	M	323	117	31	59
	F	372	93	39	69

* Recaptured within monthly 4-day trapping periods.

TABLE 2

AVERAGE DISTANCE BETWEEN SUCCESSIVE CAPTURES OF POLYNESIAN RATS AND PERCENT OF SUCCESSIVE CAPTURES AT THE SAME LOCATION AND WITHIN 75 FEET OF THE PREVIOUS CAPTURE, DURING FOUR SEASONS

SEASON AND CANE AGE	SEX OF RATS	NUMBER OF RATS TAGGED	NUMBER OF RECAPTURES	AVERAGE DISTANCE (FEET)	PERCENT RECAPTURES AT 0 FEET	PERCENT RECAPTURES WITHIN 75 FEET
Winter, 7–9 mo	M	197	150	106	23	54
	F	146	127	106	36	70
Spring, 10–12 mo	M	128	50	95	44	66
	F	90	48	103	35	73
Summer, 13–15 mo	M	119	35	98	34	74
	F	112	53	78	43	77
Fall, 16–17 mo	M	79	17	22	71	100
	F	81	27	34	67	93
Summary	M	523	252	97	32	62
	F	429	255	92	41	73

her during a routine trapping program 3,600 feet from her original capture site. She had traversed a gulch, two mature sugarcane fields, and then another gulch to reach the 8-month-old sugarcane field where she was apparently residing.

Radiotelemetry

Polynesian rats adjusted readily to the 5-g transmitters. From laboratory observations, we believe that these rats carry on their normal activities after an adjustment period of about

TABLE 3

PERCENT OF POLYNESIAN RAT LOCATIONS OBTAINED BY RADIOTELEMETRY AT VARIOUS DISTANCES FROM THE HOME BURROW

CANE AGE (MONTHS)	NO. RATS OBSERVED	DISTANCE FROM BURROW (FEET)			
		0–100	101–200	201–300	301 +
7	5	27	36	17	20
10	5	57	17	5	21
12	6	75	20	5	0
15	5	56	3	19	22
22	5	79	21	0	0
Mean		52	23	11	14

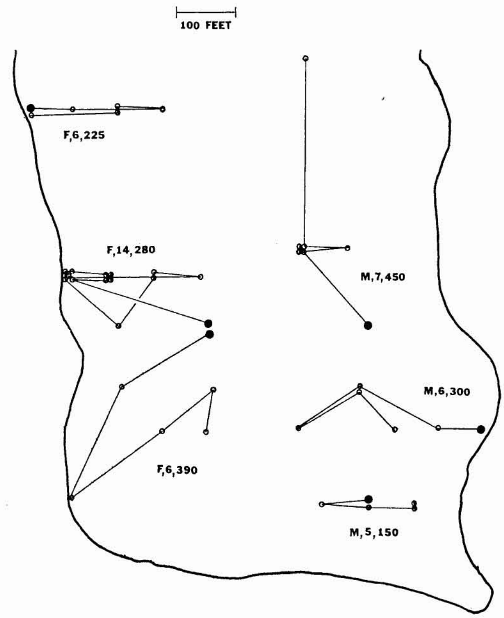

FIG. 3. Selected range maps of six Polynesian rats in Field 3S as determined by livetrapping. Compare to lower one-third of Fig. 2.

KEY: Sex, number of captures, observed range length in feet. A solid circle identifies the site of first capture; open circles are sites of later captures, connected by lines showing their orders of occurrence in time.

1 hour following transmitter attachment. Transmitter-equipped rats, recaptured from the field, had maintained their weight. No predation or mortalities to the 26 rats equipped with transmitters were observed during the five monitoring periods.

The percentages of the rats' plotted locations at various distances from their burrows for the five monitoring periods are shown in Table 3. For convenience, we have arbitrarily divided the distances into 100-foot intervals. An average of 23 locations (range 11 to 87) were plotted per rat for the 26 rats fitted with transmitters.

SEVEN-MONTH-OLD SUGARCANE (December 1967): The young cane was upright and no cane debris was on the ground. Less than 1 percent of the stalks were damaged by rats and most of the damage was located on the field edges. Only two of the five rats observed ranged over 250 feet from their burrows. A 68-g male consistently foraged 300 to 400 feet from his burrow; a 67-g female remained within 50 feet of her burrow. Although all of these rats occupied gulch burrows, four spent most of each night in the sugarcane field, whereas the fifth was found in the gulch during 60 percent of the bearings.

TEN-MONTH-OLD SUGARCANE (March 1968): During this period the sugarcane was beginning to lodge and several inches of dead leaves covered the ground. Fifteen percent of the stalks were rat damaged. The five rats followed were within 100 feet of their burrows during 57 percent of the bearings but one rat was monitored 950 feet from his burrow. Again, four rats were consistently found in the sugarcane field, but the fifth was in the gulch during 45 percent of the observations.

TWELVE-MONTH-OLD SUGARCANE (May 1968): By May, the sugarcane had lodged, recumbent stalks and leaves had formed a 6- to 12-inch mat, and 21 percent of the stalks were rat damaged. The six rats followed were within 100 feet of their respective burrows during 75

TABLE 4

MOVEMENTS OF TRANSMITTER-EQUIPPED POLYNESIAN RATS FROM THEIR BURROWS

	RATS WITH CANE FIELD BURROWS		RATS WITH GULCH BURROWS		ALL RATS			
					MAXIMUM DISTANCE FROM BURROW (FEET)			
CANE AGE (MONTHS)	NO.	MEAN MAXIMUM DISTANCE FROM BURROW (FEET)	NO.	MEAN MAXIMUM DISTANCE FROM BURROW (FEET)	NO.	MEAN	RANGE	STANDARD DEVIATION
7	0	–	5	308	5	308	108–759	288
10	3	186	2	698	5	391	104–953	340
12	2	176	4	232	6	213	89–473	144
15	4	173	1	321	5	203	41–524	213
22	4	87	1	194	5	109	54–194	55
Total	13		13		26			

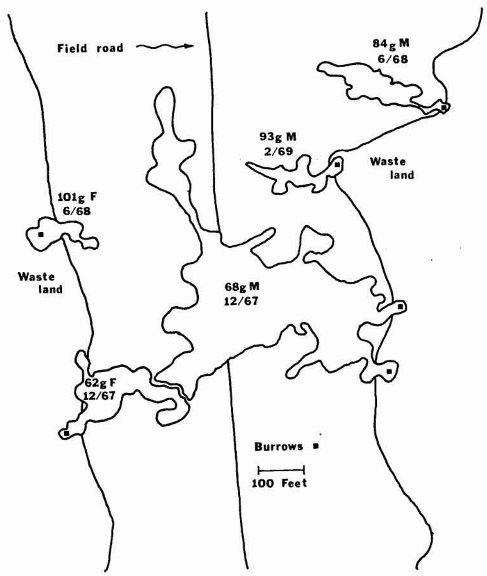

FIG. 4. Home range maps of five Polynesian rats in Field 3S as determined by radiotelemetry bearings. Compare with the middle one-third of Fig. 2.

KEY: Body weight, sex, and month and year monitored.

percent of the bearings. All except one foraged in the cane field. One rat did not move over 100 feet from its burrow, two other rats did not move over 150 feet, and two additional ones did not move over 250 feet. The sixth rat was found once, more than 250 feet from its burrow.

FIFTEEN-MONTH-OLD SUGARCANE (September 1968): By September, the sugarcane had formed a dense mat layer and rat-damaged stalks averaged 29 percent. Although three of five rats followed were never monitored over 100 feet from their burrows, 22 percent of the bearings from the five showed movements exceeding 300 feet. The two wide-ranging rats foraged in areas 200 to 400 feet from their burrows.

TWENTY-TWO-MONTH-OLD SUGARCANE (February 1969): In February, the cane had a 2-foot mat layer on the ground and 33 percent of the stalks were rat damaged. The five rats followed were found within 100 feet of their burrows during 79 percent of the bearings. Two rats did not move over 100 feet from their burrows, two did not move more than 150 feet, and the fifth occasionally moved 150 to 200 feet. The rats were rarely monitored in the gulch during the last two periods.

PATTERNS THROUGHOUT THE CROP CYCLE: Rats with burrows in gulches moved farther than rats living in the sugarcane field (Table 4). Gulch residents often foraged in the cane field (Fig. 4), but cane field residents seldom were found in the gulches. As the sugarcane became older, more of the rats from gulches occupied burrows in the field. Cane fields do not have much ground cover before the crop is about 9 months old and few burrows are found in fields before this time. Although three of five rats had field burrows in the 10-month-old sugarcane, ground cover in this field was still sparse. Two of these rats had found previously used burrows next to the concrete bunker. The third had dug a burrow on a sharp slope where the sugarcane had lodged prematurely.

The data obtained by radiotelemetry, like that obtained by livetrapping, showed a tendency toward greater movement by males than by females. Maximum movements for the two sexes (M vs. F) averaged 397 vs. 174 feet in 7-month-old cane, 563 vs. 133 feet in 10-month-old cane, 356 vs. 142 in 12-month-old cane, 301 vs. 55 feet in 15-month-old cane, and 131 vs. 94 feet in 22-month-old cane. Both sexes showed a tendency toward shorter movements as the sugarcane became older.

Rats were generally inactive in their burrows during daylight hours but, as evening approached, they became active. Gulch rats would soon move out of the gulch and into the cane fields where they foraged throughout the night. At dawn, they again were in or near their burrows; at full light of day, activity generally ceased except for occasional movements within the burrow system. On two occasions during daytime monitoring, rats with gulch burrows were found actively moving in the sugarcane field. Movements or activity periods did not change with moon phases or with rainfall.

DISCUSSION AND CONCLUSIONS

The data from this study allow a comparison of trap–retrap data with radiotelemetry data collected during approximately the same time period from the same rat population. By available criteria (Spencer and Davis 1950, Kartman and Lonergan 1955, Harrison 1958, Jackson and Stecker 1962, Tomich 1970), results here indicate that Polynesian rats are relatively sedentary. Sixty-five percent of the successive captures were within 75 feet of each other and 86 percent of the radiotelemetry bearings located the rats within 300 feet of their burrows. Both types of data also showed that females tend to move shorter distances than do males.

Trapping and telemetry both indicate that the rats' movements are influenced by the growth and development of sugarcane. As the crop matures and provides more food and cover, the home ranges of both sexes become smaller. The radiotelemetry data showed that all rats live in the gulches in the early stages of the crop cycle, although many forage into the field. However, as soon as ground cover is adequate, some rats begin to dig burrows in the field. In this study, this occurred when the cane was about 9 months old, but the timing may be influenced by other factors such as rainfall, soil fertility, and cane variety. As the crop matures and more rats dig cane-field burrows, movement between the field and gulches decreases. Rats that establish cane-field burrows reduce their home ranges and seldom leave the field. Similar data were recorded by Nass et al. (1971*a*), who found that, as the crop matures, movement by Polynesian rats between the gulch and the field interior decreases, but does continue between the gulch and the field edges.

The data from this study should help sugarcane plantations plan rat control programs. Although mechanical harvesting virtually eliminates field rat populations (Nass et al. 1971*b*), the adjoining gulch areas provide excellent rat habitat for large numbers of rats, some of which gradually invade new fields once cover is adequate. A crop protection program should, therefore, emphasize reduction of rats in the gulches before they become established in the fields. However, since many field residents are not affected by gulch or field perimeter baiting (Lindsey et al. 1971), control should be conducted in both the gulches and fields during the last 12 to 14 months of the crop cycle.

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